III. <u>REMARKS</u>

A. Introduction

This invention generally relates to multi-polarization active array transmit antennas. In particular, the application describes a chip comprising phase shifters that control the scan angle, linear polarization, and circular polarization of an RF signal.

B. Amendments

Claims 12-21 were previously withdrawn in response to a restriction requirement.

Claims 11 and 33 have been cancelled.

Claim 30 is currently amended.

Claims 39-45 have been added.

In sum, claims 1-10, 22-32, and 34-45 are pending. All amendments are supported by the specification and therefore add no new matter. In particular, claims 42 and 43 repeat features of prior claims. In regard to claims 39-41 and 44, the specification discloses a Lange coupler 312 (which is a type of quadrature hybrid coupler) on the same chip as an attenuator and phase shifters, wherein the circuit controls scan angle, linear polarization, and circular polarization. See Figure 1 of the application and the discussion in Section C below. In regard to claim 45, the specification support for the role of the attenuator in controlling circular polarization is explained below.

C. Rejection of Claims 1-10, 22-32 and 34-38 Under 35 U.S.C. §112, first paragraph, as failing to comply with enablement requirement.

The Examiner rejected of claims 1-10, 22-32 and 34-38 under 35 U.S.C. §112, first paragraph, as failing to comply with enablement requirement because "the specification

fails to sufficiently disclose to a skilled artisan how the attenuator controls the scan angle and/or the linear polarization." Office Action, p. 2.

Accordingly, applicants describe below how the attenuator controls the scan angle and the linear polarization.

Applicant first notes that although paragraph [0033] of the specification discloses that the attenuators are used "to swamp out impedance variations to attain the desired impedance matching," by definition an attenuator is a component that "attenuates" an RF signal. This function was not described in the specification because it is fundamental to the nature of an "attenuator" and is well-known to those skilled in the art. All other properties of the attenuator, like impedance matching or beam shaping, are derived from the fact that attenuators attenuate RF signals. The original specification assumed that any skilled artisan reading the specification knows that attenuators attenuate RF signals. The applicant only described the property of the attenuator that is not obvious, such as swamping-out impedance variations to attain the desired impedance matching. It is through the fundamental attenuating function and disclosed impedance matching function of attenuators that embodiments of the invention may use attenuators to control linear polarization and scan angle.

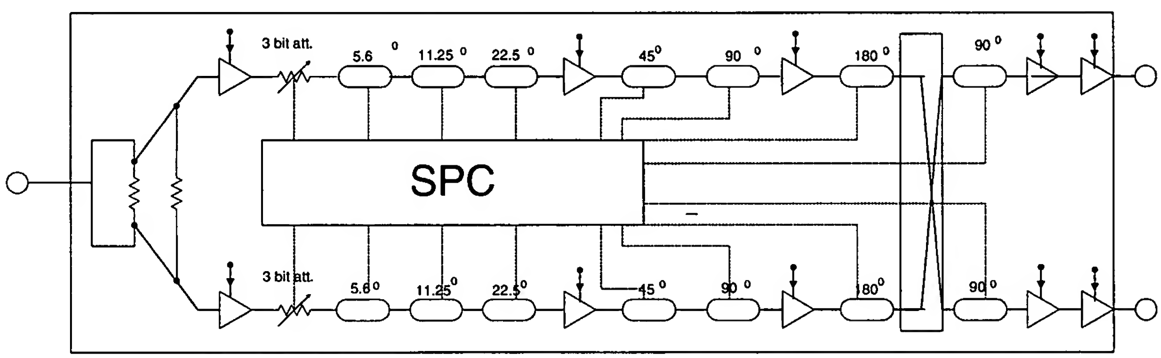
The Examiner also notes that the specification "distinguishes between the attenuator and amplifiers". By definition, amplifiers only amplify the signals, e.g., to compensate for the components' signal losses. It equally amplifies V_1 and V_2 in Formula I, therefore, it does not affect the polarization angle. An attenuator is required to adjust V_1 and V_2 individually for controlling the polarization or scan angles. An attenuator can

similarly be used in some embodiments to control the scan and circular polarization angles. As known to those skilled in the art, a variable gain amplifier can be used as an attenuator.

As described below, using a straightforward application of signal theory to the circuit described in the specification well-known to skilled artisans, a person skilled in the art of active transmit array antennas could readily understand from the specification how the attenuators control scan angle and linear polarization.

1. Attenuator Control of Linear Polarization is disclosed

Attenuator control of linear polarization can be readily deduced from the specification by a skilled artisan. As shown in Graphic 1 below (modeled on Figure 1 of the specification), signals are output from attenuators 304 and phase shifters 305-310 into Lange Coupler 312.



Graphic 1: GaAs Transmit Chip Disclosed in Application Figure 1

The input voltages V_{in1} and V_{in2} into the Lange coupler 312 are described by the following functions:

$$V_{in1} = V_1 \cos(\omega t)$$

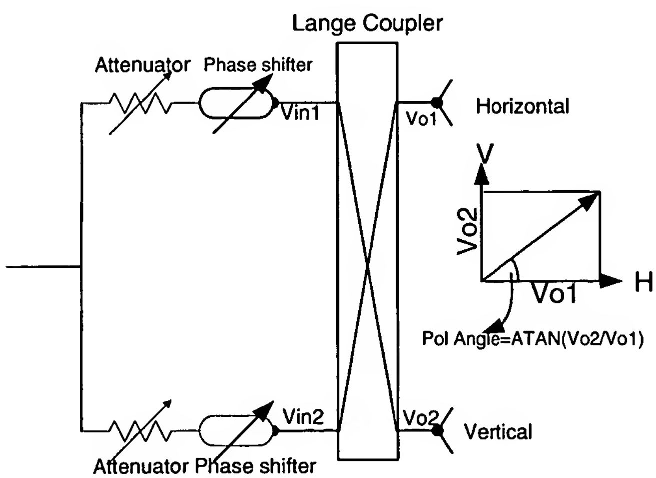
$$V_{in2} = V_2 \cos(\omega t + \Phi)$$

where V_1 and V_2 are the amplitudes of the corresponding input signals, ω is the angular frequency, t is time, and Φ is the phase difference between the two inputs. By definition, attenuators 304 can attenuate the voltage of a signal and therefore can affect (e.g., attenuate) input voltages V_{in1} and V_{in2}. Also by definition, phase shifters 305-310 can control the phase difference between the two input signals.

There is a 90 degree phase shifter between the output ports of the Lange coupler 312. According to basic electronic signal theory, the amplitude of the Lange coupler's 312 output signal (into phase shifters 3092) depends on the phase difference between the two input signals (from phase shifter 310). A skilled artisan would readily deduce that the output voltages V_{o1} and V_{o2} of the Lange coupler 312 are governed by the following functions:

$$V_{o1} = 0.707\ V_1 \cos(\omega t - 90) + 0.707\ V_2 \cos(\omega t + \Phi - 180)$$

$$V_{o2} = 0.707\ V_1 \cos(\omega t - 180) + 0.707\ V_2 \cos(\omega t + \Phi - 90)$$



Graphic 2: Principals of Linear Polarization

At any instance of time, say t = 0:

$$V_{o1} = 0.707\ V_1 \cos(-90) + 0.707\ V_2 \cos(\Phi - 180)$$

$$V_{o2} = 0.707\ V_1 \cos(-180) + 0.707\ V_2 \cos(\Phi - 90)$$

After simplification:

$$V_{o1} = -\ 0.707\ V_2 \cos(\Phi)$$

$$V_{o2} = -\ 0.707\ V_1 + 0.707\ V_2 \sin(\Phi)$$

According to basic signal theory, the linear polarization angle Θ is:

$$\Theta = \mathrm{ATAN}\ (V_{o2}/V_{o1})$$

Substituting for V_{o2} and V_{o1}, a skilled artisan would readily deduce that:

$$\Theta = \mathrm{ATAN}\ [(V_2 \cos(\Phi)) / (V_1 - V_2 \sin(\Phi))] \qquad \textbf{[Equation I]}$$

The above formula (Equation I) shows that the linear polarization angle, Θ, is a function of V_1, V_2, and Φ. A change in any of V_1, V_2, and Φ would change the scan angle. Figure 1 shows that V_1 and V_2 can be controlled and adjusted by two attenuators 304 independently, and Φ can be controlled and adjusted by the phase shifters 305-310. By modifying V_{o1}, V_{o2}, and Φ, both attenuators 304 and phase shifters 305-310 can be used to control the linear polarization angle. As noted above, this would be readily apparent to a person skilled in the art of active transmit array antennas.

2. Attenuator Control of Scan Angle is disclosed

Similarly, attenuator control of scan angle can be readily deduced from the specification by a skilled artisan. For explanatory purposes, the elements of an Active Array Antenna are shown in Graphic 3, attached hereto as Exhibit A.

The amplitude of the signal at scan angle Θ is:

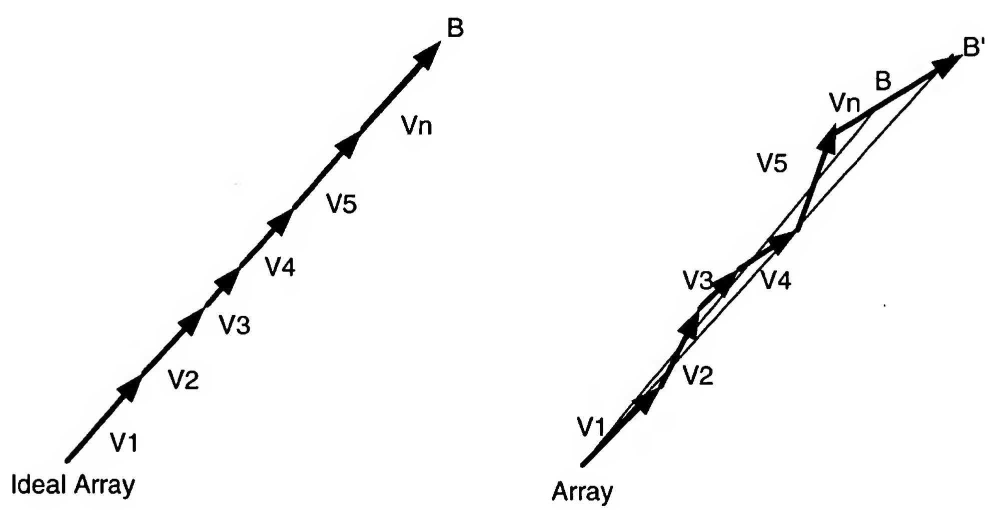
$$A(\Theta) = \Sigma\ a_k\, e^{-j\,[\,2\Pi d\,(k-1)\sin(\Theta) + \Phi k\,]\,/\,\lambda}$$

where a_k is the amplitude of the active array element and Φ_k is the phase of the active array element. In order to scan the beam to Point B, which has a scan angle of Θ, the phase difference Φ_k between the elements should be:

$$\Phi_k = - 2\Pi d\ (k-1) \sin(\Theta) / \lambda.$$

In an ideal array, to scan the beam to Point B, the phase difference between the elements must be identical so that their vector sum directs the cumulative beam to point B. In a practical active array (especially small arrays), Φ_k varies from element to element. This causes the scan angle to be skewed to the element with the largest amplitude. To address this problem, some embodiments of the invention use an attenuator to reduce the output power of the dominant element (e.g., V_n) and correct the scan angle.

In Graphic 4 below, V_1, V_2, V_3, V_4, V_5, and V_n are the vector representations (phase and amplitude) of the output power of the elements:

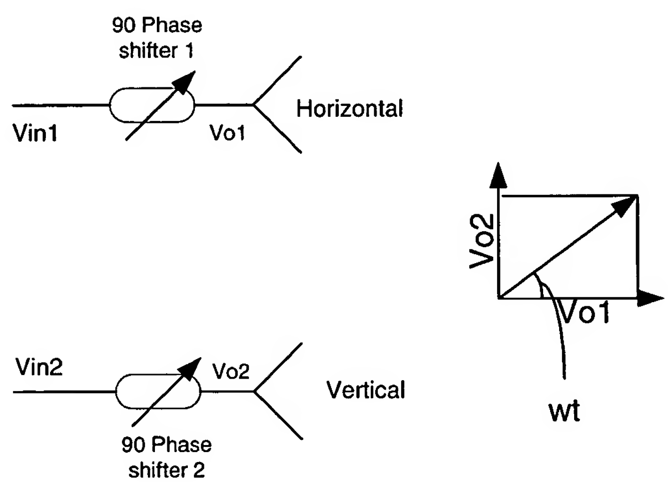


Graphic 4: Phase Line-Up in Ideal and Non-Ideal Arrays

The left side of Graphic 4 shows an ideal array with aligned elements, and the right side of Graphic 4 shows a real array with imperfectly aligned elements. While the goal of the array is to scan the beam to Point B (i.e., to have the resultant vector point in the direction of B), the beam of the real array is instead skewed to Point B´. By reducing the amplitude of one or more imperfectly-aligned elements (e.g., the dominant element V_n in the combination shown on the right side of Graphic 4), the attenuators allow for the correction and control of scan angle.

3. Attenuator Control of Circular Polarization is disclosed

The simplified portion of the transmitter chip that controls the circular polarization angle is shown in Graphic 5 below.



Graphic 5: Principles of Circular Polarization

In order to achieve circular polarization the phase difference between V_{o1} and V_{o2} should be 90°. The 90° Phase Shifter #1 controls the left hand circular polarization

(LHCP) angle, and the 90° Phase Shifter #2 controls the right hand circular polarization (RHCP) angle. The input voltages are governed by the equations:

$$V_{in1} = V_1 \cos(\omega t)$$

$$V_{in2} = V_2 \cos(\omega t)$$

where V_1 and V_2 are input signal amplitude and ω is angular frequency.

For LHCP, phase shifter #1 is on and phase shifter #2 is off. Accordingly, V_{o1} and V_{o2} are:

$$V_{o1} = V'_1 \cos(\omega t\text{-}90)$$

$$V_{o2} = V'_2 \cos(\omega t)$$

where V'_1 and V'_2 are the signal amplitudes at the outputs of the phase shifters (phase shifter losses). These equations reduce to the following:

$$V_{o1} = V'_1 \sin(\omega t)$$

$$V_{o2} = V'_2 \cos(\omega t)$$

For RHCP, phase shifter #2 is on and phase shifter #1 is off. The V_{o1} and V_{o2} are:

$$V_{o1} = V'_1 \cos(\omega t)$$

$$V_{o2} = V'_2 \cos(\omega t - 90)$$

where V'_1 and V'_2 are the signal amplitudes at the outputs of the phase shifters (wherein the [´] indicates signal loss due to the phase shifters as compared to V_1 and V_2). These equations reduce to the following:

$$V_{o1} = V'_1 \cos(\omega t)$$

$$V_{o2} = V'_2 \sin(\omega t)$$

Thus, embodiments of the invention can accordingly achieve circular or elliptical polarization by adjusting the amplitude V'_1 and V'_2, which can be adjusted and controlled by attenuators 304. In order to achieve a circular polarization with a good axial ratio, V'_1 and V'_2 must be the same. This can be achieved by adjusting the attenuators of each signal.

Thus, the attenuator can be used to adjust and control linear polarization, circular polarization, and the scan angle of an active array antenna, e.g., by controlling V'_1 and V'_2.

4. Summary

Sections C(1)-(3), above, show that the amplitude of the signals entering cross polarized radiators have an affect on the linear polarization, circular polarization, and scan angles of the active array antenna. The amplitude of the signals entering the radiators is controlled by attenuators and amplifiers. The function of the attenuators is to adjust the amplitude of the signals. Thus, as shown in the straightforward equations above, the linear polarization, circular polarization, and scan angle can be controlled by controlling the amplitude of the signals using attenuators.

While the discussion in §§ C(1)-(3) was provided at the request of the Examiner, Applicant submits that this explanation would be apparent to a person skilled in the art of active transmit array antennas from Applicant's original disclosure. In particular, the use of attenuators to control linear polarization, scan angle, and circular polarization would be apparent to a skilled artisan from the circuit diagram of Figure 1 and the passages of the specification relating to attenuators.

Accordingly, the Applicant respectfully requests the Examiner to withdraw the instant rejection of claims 1-10, 22-32, and 34-38.

D. Rejection of Claims 1-10, 22-32 and 34-38 Under 35 U.S.C. §112, second paragraph, as being indefinite.

The Examiner rejected claims 1-10, 22-32 and 34-38 under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. The Examiner requests that the Applicant show "how the attenuator provides each of the scanning control and linear polarization control."

The Applicant has explained in detail how the attenuator provides scanning control and linear polarization control above, e.g., in §§ C(1)-(3). Accordingly, the Applicant respectfully requests the Examiner to withdraw the instant rejection of claims 1-10, 22-32, and 34-38.

E. Rejection of Claims 1-10, 22-32 and 34-38 Under 35 U.S.C. §102(b) as being anticipated by Mohuchy.

The Examiner rejected claims 1-10, 22-32 and 34-38 as being anticipated by U.S. Patent No. 5,933,108 to Mohuchy ("Mohuchy").

Claim 1 recites "a first series of phase shifters and at least one attenuator to control the scan angle and linear polarization of an RF signal; and a 90° phase shifter to control the circular polarization of an RF signal." Claim 22 recites "means for controlling the scan angle and the linear polarization of an RF signal, wherein said means comprises at least one attenuator for controlling the linear polarization of the RF signal" and "means for controlling the circular polarization of the RF signal." Claim 30 recites "a gallium

arsenide transmitter chip comprising: a first series of phase shifters; and at least one attenuator; wherein the [phase shifters and attenuator] control the linear polarization of an RF signal." Claims 2-10, 22-29, 31, 32, and 34-38 depend from these claims and therefore incorporate these elements by reference.

Mohuchy discloses a phase shifting integrated circuit chip (PSIC) as shown in Figure 2a of the Mohuchy disclosure. This 0.25x0.25" GaAs chip contains only phase shifters, amplifiers, and digital circuits. Thus, Mohuchy fails to disclose an attenuator as recited in claims 1-10, 22-32 and 34-38.

Mohuchy discloses four PSIC and two RPMT chips in a test fixture as shown in Figures 1 and 6 to build a microwave vector controller for controlling the amplitude and phase characteristics of an RF signal. This large circuit (6 GaAs chips) disclosed in Mohuchy can only produce linear polarization. The Mohuchy chip cannot produce (or control) circular polarization, and it is not capable of producing (or controlling) scan angle. Thus, Mohuchy fails to disclose controlling circular polarization and controlling scan angle as recited in claims 1-10 and 22-29. Further, Mohuchy fails to disclose a single GaAs chip that controls linear polarization, as recited in independent claim 30.

The Examiner did not specifically assert that Mohuchy teaches various dependent claim elements, nor did the Examiner show where such elements were disclosed in the reference. For instance, the Examiner did not mention such elements as 5.625 degree phase shifters (claim 3), a 3-bit attenuator and three single-stage amplifiers (claim 4), TTL used to control polarization and scan angle (claim 5), etc. Applicant submits that Mohuchy fails to disclose all dependent claim elements not specifically mentioned by the Examiner.

For at least these reasons, Mohuchy fails to teach the elements of claims 1-10, 22-32, and 34-38. Accordingly, Applicant respectfully requests the Examiner to withdraw the instant rejection of these claims.

F. Rejection of Claims 1-10, 22-32 and 34-38 Under 35 U.S.C. §103(a) as being unpatentable over Fassett in view of Jacomb-Hood and Nathanson.

The Examiner rejected claims 1-10, 22-32 and 34-38 as being unpatentable over U.S. Pat. No. 4,088.970 to Fassett et al. ("Fassett") in view of U.S. Pat. No. 4,806,944 to Jacomb-Hood ("Jacomb-Hood") and U.S. Pat. No. 4,823,136 to Nathanson et al. ("Nathanson").

Fassett discloses a phase shifter / polarization switch comprising a phase shifter, a combiner, and a divider. Fassett's circuit is capable of providing a scan angle and any one of six separate polarization senses (vertical, horizontal, and $\pm$ 45° linear polarization, and left hand and right hand circular polarization). The polarization switch is shown in Figure 4 of the Fassett disclosure.

Fassett fails to disclose an attenuator. Thus, Fassett fails to disclose using an attenuator to control scan angle. Similarly, Fassett fails to disclose using an attenuator to control linear polarization.

Jacomb-Hood discloses an attenuator in the path between a transmitter power amplifier and a radiator of a steerable active array antenna to compensate for the mismatching that occurs when the antenna is steered away from a bore sight. See Figures 2 and 3 of the Jacomb-Hood disclosure. Jacomb-Hood does not disclose using an attenuator to control scan angle or linear polarization, nor does Jacomb-Hood suggest

using an attenuator for anything other than its disclosed purpose of compensating mismatching (i.e., preventing loss of power to the antenna).

Nathanson discloses a Transmit/Receive (T/R) module that is fabricated on a GaAs substrate/chip. This GaAs chip does not contain a digital controller (e.g., an SPC) as shown in Figure 2 of the Nathanson disclosure. Thus, Nathanson's circuit is not capable of providing a polarized signal, either linear or circular.

Nathanson discloses an attenuator at the input of the T/R module (Figure 2). However, Nathanson does not disclose the function of the attenuator. In particular, Nathanson does not disclose using an attenuator to control linear polarization or scan angle. Regardless of disclosure, the attenuator in Nathanson cannot be used to control the linear polarization angle.

The amplifiers in the Nathanson circuits only provide amplification to the RF signal. The gain control is defined as maintaining a flat RF signal across the frequency band (col. 7, line 31 - col. 8, line 5). Nathanson does not disclose controlling amplitude to control the polarization angle or scan angle.

Thus, none of the cited references disclose using an attenuator to control linear polarization. Thus, the combination of these references does not teach using an attenuator to control linear polarization, as recited (or incorporated) in claims 1-10, 22-32 and 34-38.

The Examiner did not specifically assert that the references teach various dependent claim elements, nor did the Examiner show where such elements were disclosed in the references. For instance, the Examiner did not assert that the references teach such elements as a serial-to-parallel converter (claim 2), 5.625 degree phase shifters (claim 3), a

3-bit attenuator and three single-stage amplifiers (claim 4), TTL used to control polarization and scan angle (claim 5), etc. Applicant submits that the asserted references fail to disclose all dependent claim elements not specifically mentioned by the Examiner.

Further, there is no motivation to combine Fassett, Jacomb-Hood, and Nathanson with one another. The Examiner has not shown an implicit or explicit motivation in any of the references to combine them with any of the other references.

The Examiner also states that "it would have been obvious…to increase the phase resolution at the expense of a greater cost by providing additional bits of resolution, each of which is half of the preceding." Applicant submits that it would not have been obvious. Such a proposal was not feasible using prior systems and methods and would not have been considered by a skilled artisan.

For at least these reasons, the combination of Fassett, Jacomb-Hood, and Nathanson fail to teach claims 1-10, 22-32, and 34-38. Accordingly, Applicant respectfully requests the Examiner to withdraw the instant rejection of these claims.

G. Rejection of Claims 1-10, 22-32 and 34-38 Under 35 U.S.C. § 103(a) as being unpatentable over Caille in view of Fassett.

The Examiner rejected claims 1-10, 22-32 and 34-38 as being unpatentable over U.S. Pat. No. 5,659,322 to Caille ("Caille") in view of Fassett et al. and Applicant's admission of the prior art use of GaAs chips.

Caille discloses a Transmit/Receive device (T/R) that is capable of providing horizontal and vertical linear polarization and left hand and right hand circular polarization. Caille achieves polarization by connecting the outputs of two T/R circuits

(52a and 52b output ports in the Figure 2 of the Caille disclosure) to a cross polarized radiator element. Caille uses phase shifter 27 to scan the beam. Caille uses attenuator (26) to shape the antenna beam and reduce secondary lobes (Column 2, lines 16-21).

As shown in Figures 3 and 4 of the Caille disclosure, Caille uses two 90° hybrid elements 5a and 5b and four one bit phase shifters (1, 2, 3, and 4) to achieve various polarization states. The circuits in Figures 1-4 and 6 do not disclose using an attenuator to control scan angle or linear polarization. Rather, the attenuator 28 of Figures 3 and 4 is used for beam shaping.

Caille fails to disclose using a phase shifter to control linear polarization. Further, Caille fails to disclose using an attenuator to control scan angle.

Fassett discloses a phase shifter and polarization switch as described above. Fassett fails to disclose an attenuator.

The teachings of Fassett and Caille cannot be combined, and their disclosures teach away from combination. Caille discloses a 2-channel T/R module. Fassett contains a coupler. It is not clear how a polarization switch (Fassett) could be combined with a T/R circuit (shown in Figure 5 of Caille). (It should be noted that the other circuits disclosed in Caille (Figures 1-4 and 6) have only a single attenuator applied to both outputs and therefore cannot possibly be used to control scan angle or linear polarization.) If the Fassett circuit were combined with a transmitter/receiver (T/R) circuit, the combination might be used for transmitting, but not receiving, and it would therefore lose half of its functionality. Thus, the references actually teach away from combination. The Applicant

requests the Examiner to explain how a relevant skilled artisan might combine the teachings of Fassett and Caille in a single embodiment.

In addition, the Fassett and Caille references contain no motivation to combine with each other. The Examiner has not shown such motivation in the references.

However, even if the teachings of Caille and Fassett were combined, the combination fails to disclose using an attenuator to control scan angle as recited in claims 1-10, 30-32 and 34-38.

Finally, the Examiner did not specifically assert that the references teach various dependent claim elements, nor did the Examiner show where such elements were disclosed in the references. For instance, the Examiner did not assert that the references teach such elements as a serial-to-parallel converter (claim 2), 5.625 degree phase shifters (claim 3), a 3-bit attenuator and three single-stage amplifiers (claim 4), TTL used to control polarization and scan angle (claim 5), etc. Applicant submits that the asserted references fail to disclose all dependent claim elements not specifically mentioned by the Examiner.

For at least these reasons, Applicant respectfully requests the Examiner to withdraw the instant rejection of claims 1-10, 22-32 and 34-38.

H. Rejection of Claims 1-10, 22-32 and 34-38 Under 35 U.S.C. § 103(a) as being unpatentable over Raby in view of Mohuchy.

The Examiner rejected claims 1-10, 22-32 and 34-38 as being unpatentable over an article entitled "Ku-Band Transmit Phased Array Antenna for use in FSS Communication Systems" by Raby et al. ("Raby") in view of Mohuchy.

Raby fails to disclose an attenuator. Mohuchy fails to disclose an attenuator and accordingly fails to disclose the deficiencies of Raby. Thus, the combination of Raby and Mohuchy fails to teach an attenuator as recited in claims 1-10, 22-32 and 34-38.

Further, the Examiner did not specifically assert that the references teach various dependent claim elements, nor did the Examiner show where such elements were disclosed in the references. For instance, the Examiner did not assert that the references teach such elements as a serial-to-parallel converter (claim 2), 5.625 degree phase shifters (claim 3), a 3-bit attenuator and three single-stage amplifiers (claim 4), TTL used to control polarization and scan angle (claim 5), etc. Applicant submits that the asserted references fail to disclose all dependent claim elements not specifically mentioned by the Examiner.

For at least these reasons, Applicant respectfully requests the Examiner to withdraw the instant rejection of claims 1-10, 22-32 and 34-38.

VI. Conclusion

Applicant respectfully submits that the claims as amended are supported by the specification and therefore add no new matter. Applicant further submits that the application is in condition for allowance and respectfully requests a notice of allowance for the pending claims. Should the Examiner determine that any further action is necessary to place this application in condition for allowance, the Examiner is kindly requested and encouraged to telephone Applicant's undersigned representative at the number listed below.

A Petition for One-Month Extension of Time is filed concurrently with this response. Applicant hereby provides authorization to charge fees associated with the filing of this response and the Petition for One-Month Extension of Time against deposit account 50-0206.

Respectfully submitted,

Date: 8/25/04 By: Thomas D. Bradshaw

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EXHIBIT A

Graphic 3: Active Array Antenna Scanned to Point B